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Biomethane
Renewable Natural Gas

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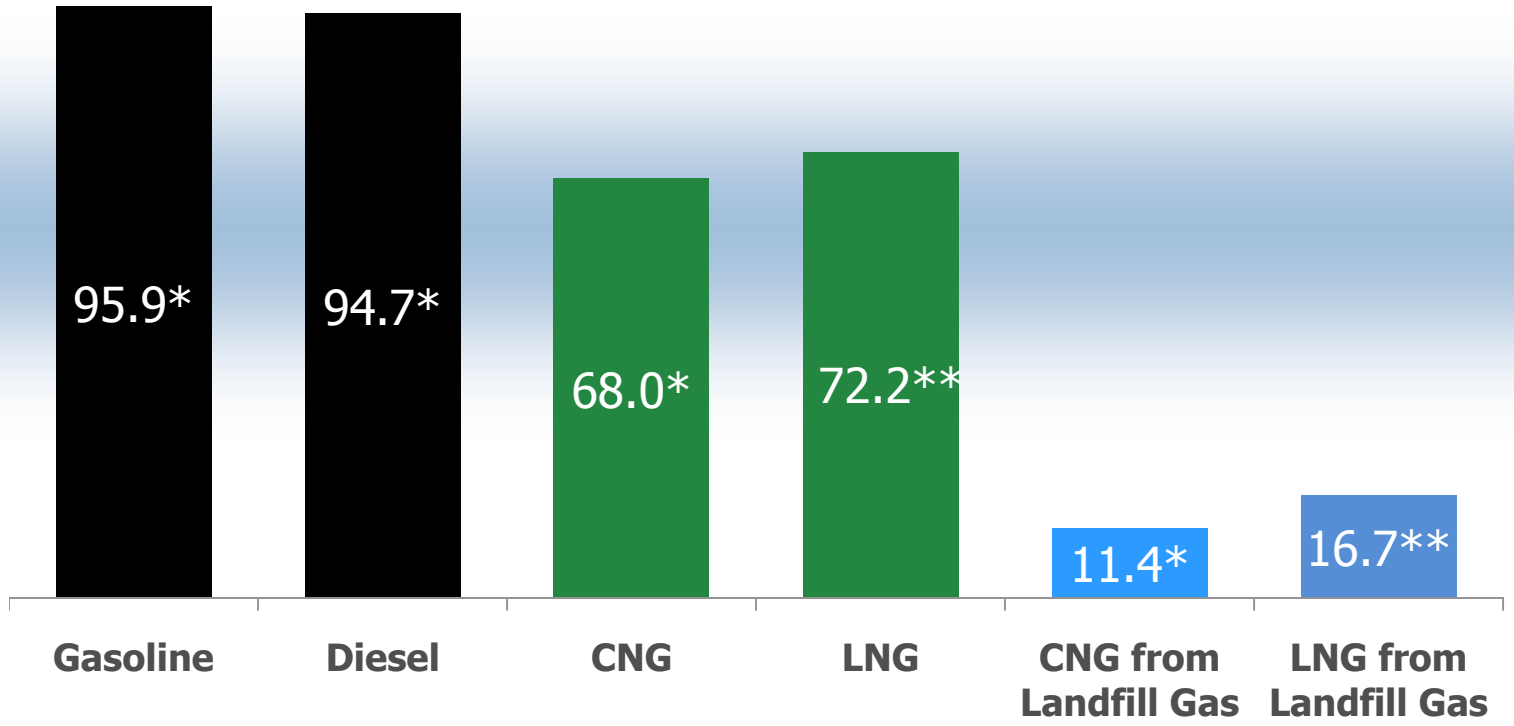
Drivers for Biomethane – A Renewable Fuel

- Public Policy increasing the value of biomethane
  - AB32 Greenhouse Gas Reductions
  - Renewable Portfolio Standard for Power Generation
  - LCFS – **Biomethane the lowest carbon fuel**
  - Proposed federal GHG and CAFE changes
  - **Clean Energy desire to offer lower carbon fuel portfolio**
- Sources of biomethane
  - **Landfills**
  - Waste water treatment plants
  - Waste digesters
    - Manure
    - Agriculture crop and green waste
  - Forest waste

What Value Carbon?

WTW Greenhouse Gas Emissions
(in grams CO2eq/MJ)



* CARB Jan 30, 2009 WTW data
** TIAX Report on Boron LNG plant

Landfill Resources in U.S. – Economies of Scale

- 254 million tons waste generated in U.S. (2007)
- 137 million tons (54%) to landfills
- McCommas landfill (Dallas, TX)
  - 30+ million tons in place
  - Adding 8,500 tons per day or 2.2 million tons/yr
  - Production of 4.5 million CF/day to pipeline
  - ~ 35,000 GGE/day (or 30MW of power)
- Cost effective gas cleanup technology
  - Require raw gas flows above 1,000 SCFM
  - Lower flow rates could produce marginal economics

Biomethane Production from Landfills

- Significant amount of contracts/infrastructure in place
  - Contracts for waste collection, transportation to landfills and tipping fees
  - Landfill and environmental air quality permits
  - Gas collection systems
  - Waste water systems
  - Solid waste – leave in place
- Need to add
  - Cost effective gas cleanup technology
  - Pipeline connections or alternatively produce LNG on site
- Pipeline access
  - Nominate biomethane anywhere in system (fuel or power gen)
  - Offer biomethane blends at fuel stations or nominate to LNG production

Landfill Gas Processing Technologies

- Pressure Swing Absorption (PSA) McCommas
- Membrane technology
- Solvent systems
  - Kryosol
  - Selexol
  - CO2 wash
  - Water based
- Sulfur removal systems – several continuous & batch systems
- Cleanup systems can involve an integration of many technologies

Economics of Landfill Biomethane

- Biomethane as transportation fuel should command a premium tied to carbon credit trading under the LCFS
- Credit generation and trading under LCFS doesn't begin until 2011 – price of carbon won't be determined until then
- Biomethane commands a premium price in the power generation market
  - Utilities strive to meet their renewable targets under the Renewable Portfolio Standard
  - CPUC has already placed a value on renewable power and hence carbon
- NGV industry is lobbying CEC and CARB for "SWAP" treatment of biomethane to eliminate need to purchase firm pipeline capacity for biomethane delivered from out of state

Landfill Gas Landscape

- 578 landfills monitored by EPA in Landfill Methane Outreach Program (LMOP)
- 422 landfill projects producing electricity
  - Emission permits for power generation projects making electricity generation less attractive
  - Restrictions on power generation can't maximize biomethane use
  - Considering shifting to gas cleanup as more viable market
- **19 pipeline quality gas projects in U.S.**
  - Using a variety of cleanup technologies
  - New technologies emerging every day
  - Gas cleanup technology is becoming cost effective for smaller landfills

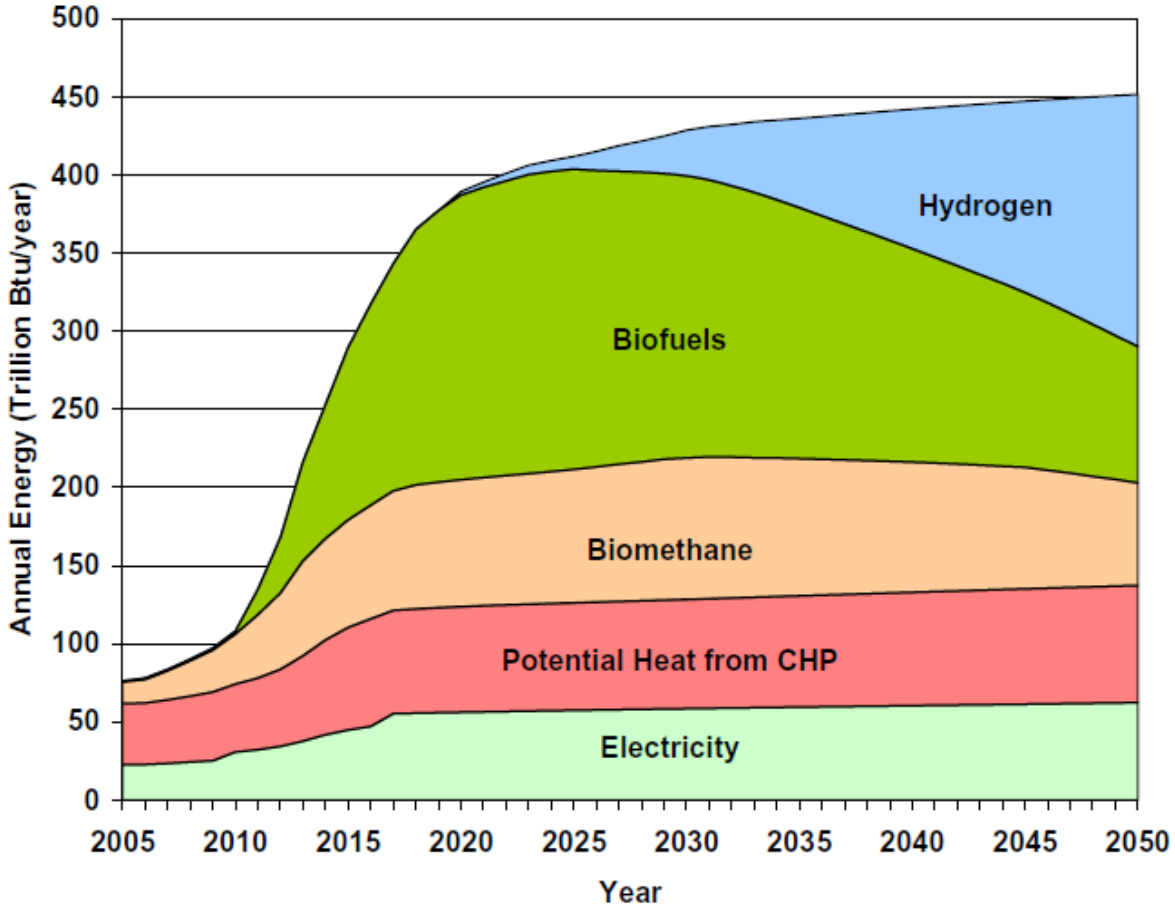
EPA Database on U.S. Landfills

578 landfills being tracked

Millions of Waste Tons in Place	Number of Landfills
1-5	273
5-10	119
10-15	69
15-20	21
20-25	25
25-30	5
30-35	12
35-40	3
40-50	7
100+	6

Note: McCommas >30 million tons of waste in place

Biomethane Potential in California



Ref: CEC Roadmap for the Development of Biomass in California 2006

California Biomass

- Market distribution of biomass
  - 100 BCF/yr methane from landfill and waste water treatment
  - 2500 MW of power generation => 135 BCF/yr methane
  - 1-2 Billion gallons/yr of liquid biofuels => 125-250 BCF methane
- Biomethane used for power generation and combined heat and power could be reallocated to pipeline biomethane
- New waste to biomethane processes will compete for agriculture waste feedstocks that have been anticipated will go to liquid biofuels

Biomethane

- Biomethane is going to play a role in NGV market development strategy
- NGV industry can use biomethane
  - More cost effectively
  - Without penalties of energy conversion and additional GHG production
  - Can utilize 100% of production capacity
- Vast untapped resources (landfills, waste water treatment, dairy/cattle, agricultural and forest wastes)
- Key
  - Achieving economies of scale in smaller and smaller production resources
  - Achieving gas clean-up sufficient to access pipeline systems

Issues CEC can address with AB118 Funding

- Effectiveness of gas cleanup technology for landfills
  - Sponsor gas sampling and testing program around the U.S. landfills that are producing pipeline quality biomethane
  - Gas sampling and testing of California utility gas to determine baseline quality of utility gas
    - Data from cleanup technology companies is that processed gas from landfills is cleaner than most utility gas
  - Initiate a study that determines whether there will be a significant dilution issue with utilities blending clean gas from landfills
- Small scale gas cleanup technology evaluation at California landfills
  - Determine cost effectiveness and performance of smaller scale systems through demonstration programs
  - Will lead to deployment of smaller scale cleanup systems to address multitude of landfill resources in Calif.
  - Same technology can be deployed for agriculture digesters

For more information:

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